Space Weather Technical Forecast

Issued on Saturday, 15 July 2023 at 01:09 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Minor/Moderate R1/R2 Blackouts likely throughout. Chance of G1/Minor Storms Day 1 (15 July). New CME awaiting analysis.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with an M1.0 flare peaking at 14/0936UTC from AR3363. This flare produced a CME by appearing to trigger an adjacent filament eruption. This has been assessed as not Earth directed. There are currently seven sunspot regions on the visible disc, as AR3361 is no longer visible on the west limb and AR3370 appears to have faded. The two most interesting regions on the disc are AR3363 and AR3372. Both are large regions with small delta spots visible. AR3373 and AR3374 have recently rotated onto the east limb, and may not yet be fully visible. AR3367 is becoming more difficult to analyse as it starts to approach the west limb.
The Sun has been relatively prolific in producing CMEs in the period, however the event of most interest occurred with a C8.8 flare peaking at 14/1844 UTC from the now faded AR3370. This appeared to trigger a small filament eruption. SDO AIA-304 imagery shows the eruption, from a position which is likely to be Earth directed, but we await coronagraph imagery for a full assessment.

Solar Wind / Geomagnetic Activity: The solar wind, as recorded by DSCOVR at L1, showed tailing weak CME effects at first, followed by a further CME arrival at 14/1525 UTC. The wind speed was initially ambient, below 400 km/s, but jumped with the CME arrival and is varying between 400-450 km/s. The density was initially average or slightly above, reaching a peak of 35 ppcc after the CME arrived. The IMF was weak to moderate, but jumped as the CME arrived, peaking at strong levels around 18 nT. The north-south component was occasionally moderately southward directed for much of the period, becoming moderately northward directed after 14/1800 UTC. Phi angle was variable. Geomagnetic activity was mostly Unsettled to Active, with a G1/Minor Storm interval 14/1800-2100 UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, has been at background levels. High energy electron flux (greater than 2MeV) was at mostly background levels. The 24-hour integrated fluence was below the Active (1e8 integrated pfu) threshold on a decreasing trend. A fluence of 1.76e6 pfu was recorded at 15/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is likely, with a slight chance of X-flares. These are most likely from AR3363 and AR3372.

Solar Wind / Geomagnetic Activity: Earth is currently experiencing weak CME effects. A further Earth directed CME is probable, but we await coronagraph imagery for a full assessment. The coronal hole forecast carries relatively high uncertainty. CH23 is likely to connect imminently, however, the duration of the fast wind is likely to be short, and should ease through

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

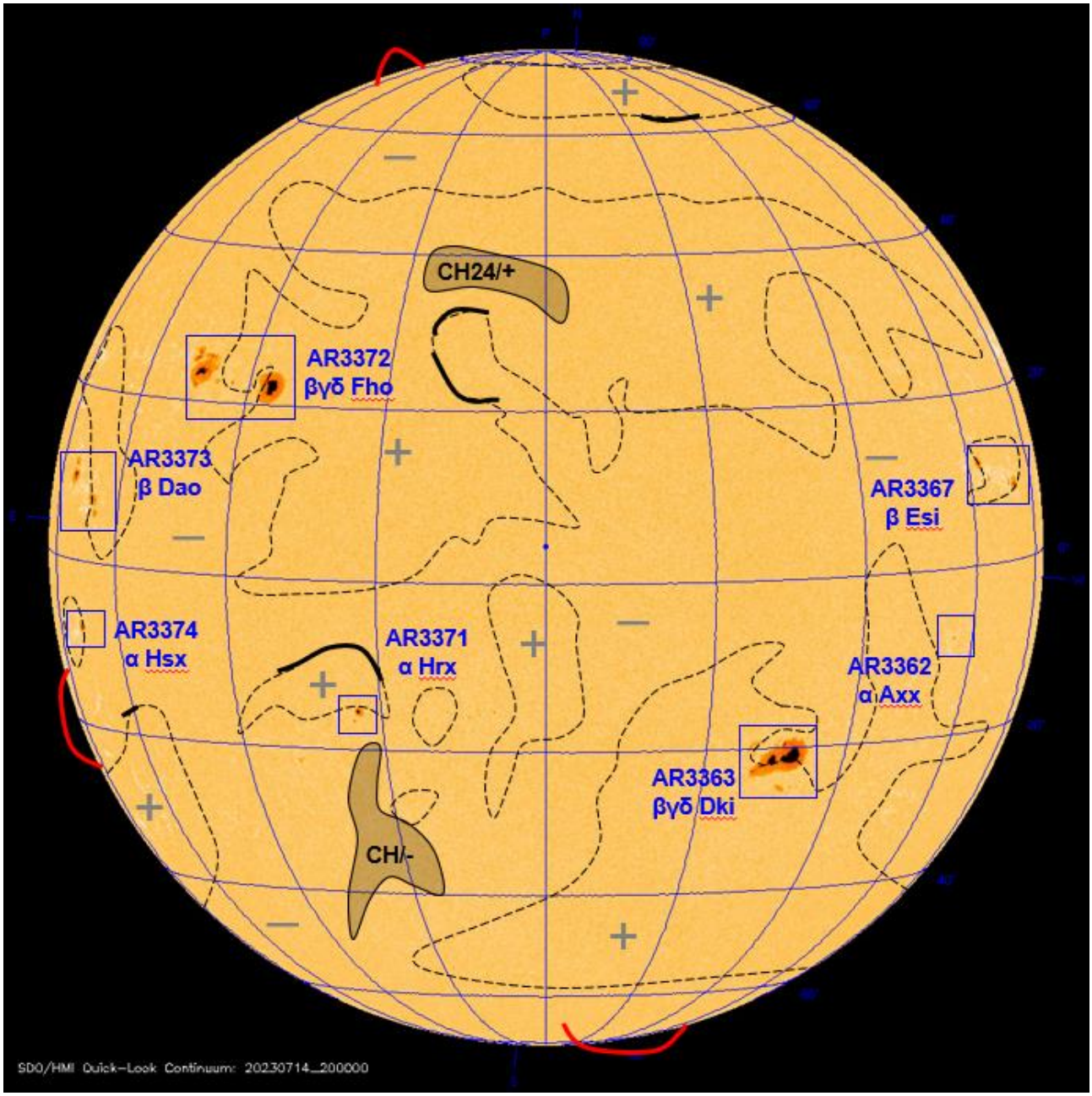
the course of the weekend. Confidence in the forecast beyond this is somewhat lower still as there may be a diffuse equatorial coronal hole succeeding CH23/-, but this is likely to have little effect at Earth.
Initially Unsettled to Active geomagnetic activity is expected, with a chance of further G1/Minor Storm intervals. Thereafter Quiet to Unsettled activity is expected, but with a likely increase at some point should the new CME mentioned above prove to be Earth directed.

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a slight chance of reaching the S1/Minor Storm threshold through the period, should any larger flares occur.
High energy electron flux (greater than 2MeV) may rise briefly over the weekend, but fluence is most likely to remain below the Active (1e8 integrated pfu) threshold throughout.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1. Solar Analysis Valid 14/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

The CME from the 11 July filament eruption arrived at L1 at 14/1525 UTC, with continuing weak effects. A further Earth directed CME is probable, from a C8.8 flare peaking at 14/1844 UTC from the now faded AR3370. This appeared to trigger a small filament eruption. SDO AIA-304 imagery shows the eruption, from a position which is likely to be Earth directed, but we await coronagraph imagery for a full assessment.

The coronal hole forecast carries relatively high uncertainty. Regarding CH23, on the previous rotation a strong connection occurred, with solar wind speeds over 600km/s, however the CH appears much-reduced and fragmented on this occasion. STEREO-A has seen a CIR type signature in the last 12 hours, which would suggest an arrival at Earth imminently. This may be somewhat masked by current CME effects, however. The duration of the fast wind is likely to be short, and should most likely ease through the course of the weekend. Confidence in the forecast beyond this is somewhat lower still as there may be a diffuse equatorial coronal hole succeeding CH23/-, although this appears less clear than in recent days, and the open field lines may have now closed. CH24/+ is small and a long way north, therefore is unlikely to give significant effects at Earth.

Initially Unsettled to Active geomagnetic activity is expected, with a chance of further G1/Minor Storm intervals. Thereafter Quiet to Unsettled activity is expected, but with a likely increase at some point should the new CME mentioned above prove to be Earth directed.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	30	5	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

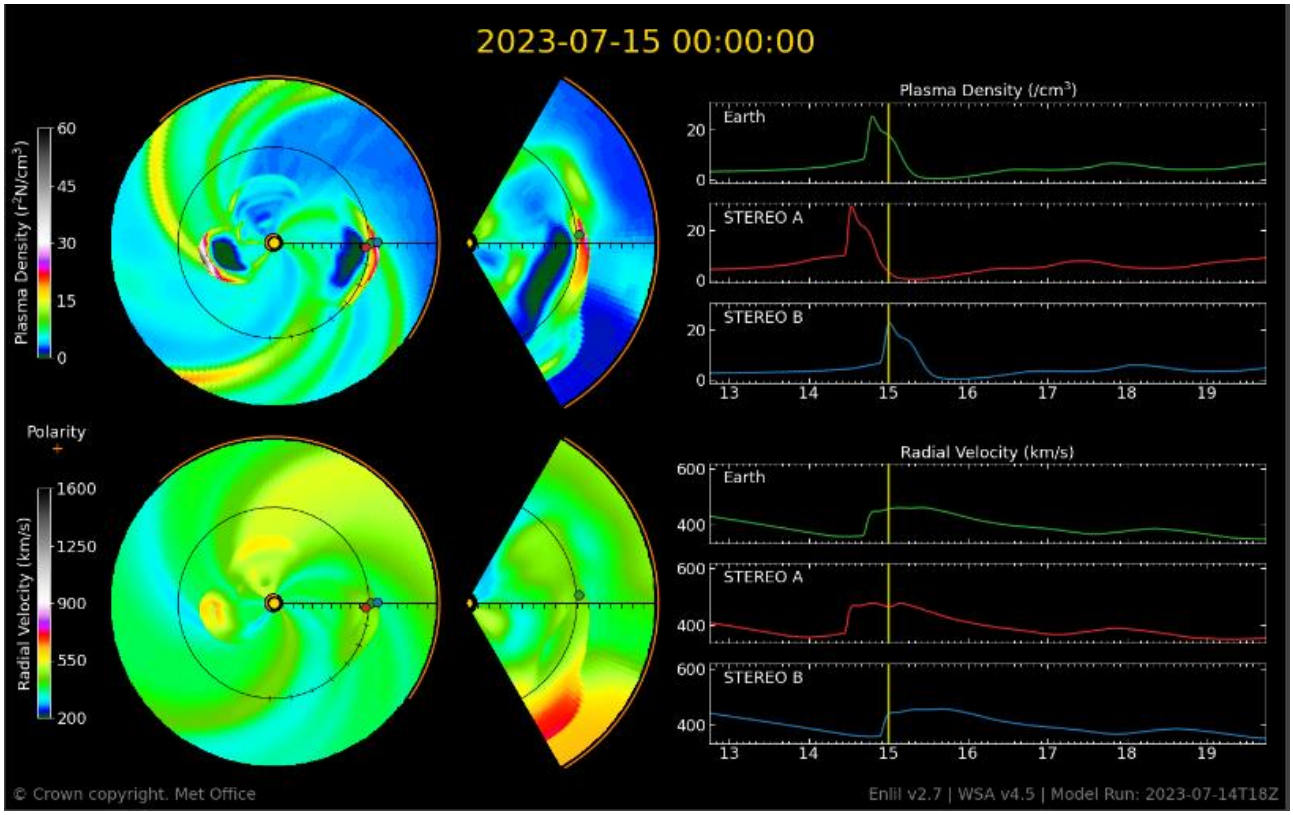
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Possible Earth directed CME, but no analysis has been completed yet due to lack of coronagraph imagery.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 2: The CME shown in Enlil arrived at Earth earlier on 14 July. A probable further CME is not yet in Enlil, awaiting analysis.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Radio Blackouts - X-Ray Flares:

Solar activity in the last 24 hours has been Moderate, with an M1 flare peaking at 14/0936 UTC from AR3363.

There are currently seven sunspot regions on the visible disc, as AR3361 is no longer visible on the west limb and AR3370 appears to have faded. The two most interesting regions on the disc are AR3363 (Dki/Beta-Gamma-Delta) and AR3372 (Fho/Beta-Gamma-Delta). Both are large regions with small delta spots visible, and both have sufficient magnetic flux for an X-flare. AR3373 and AR3374 have recently rotated onto the east limb, and may not yet be fully visible. AR3367 is becoming more difficult to analyse as it starts to approach the west limb.

Activity is expected to be Low to Moderate, with a likelihood of M-class flares and a slight chance of X-class flares. These most likely from AR3372 and AR3363. Although some regions will leave the disc during the period, far side soundings and far side CME activity suggest the presence of several fairly active regions to rotate onto the disc in the coming days. As such, the flare risks are held constant for now, although the oncoming regions cannot be assessed until they become visible on the east limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: X-ray flare activity just reached Moderate levels in the last 24 hours.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

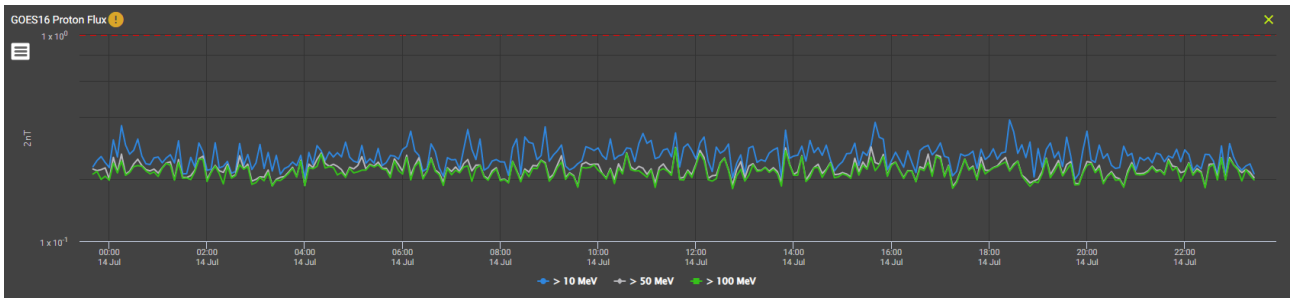
© Crown Copyright 2023. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. There has been some minor enhancement in response to some of the past week's M-class flares, but these have now eased.

There is a slight chance of protons rising towards the S1/Minor Radiation storm level, given any significant flaring from the spots on the western limb. The daily risk stays roughly constant - as the current western regions cross the horizon onto the far side and rotate away, there are further groups moving westwards to take their place.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Proton flux at GOES16 has now returned to background levels.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

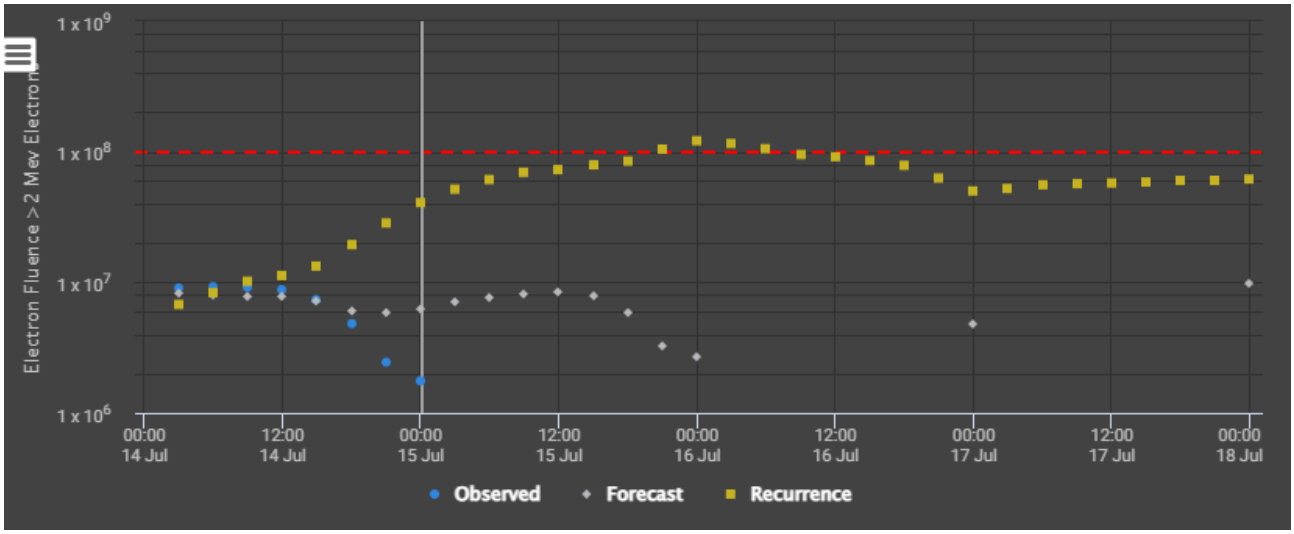
© Crown Copyright 2023. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) at GEO has been at mostly background levels, with a declining trend, likely due to recent CME arrivals. An increase of electron flux in the Van Allen belt is possible due to the combined effect of the CME and potential fast wind enhancement. However, a possible further CME later in the period may cause another suppression, although this CME has yet to be fully assessed. Any flux rise through the weekend has low confidence in magnitude.

The associated 24-hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold, with REFM giving a reasonable guide, although it won't be taking account of any further CME arrivals. There may be a brief rising trend over the weekend, but the potential further CME arrival is likely to suppress this once again. It is considered most likely that fluence will remain below Active levels throughout.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: MOSWOC REFM showing a below Active trend through the coming days, which seems reasonable.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.